ComEd
An Exelon Company

Distributed Resources on Spot Networks at ComEd

ComEd's protection philosophies ensure a reliable and safe design for ComEd's system, ComEd's customers, and the connecting distributed resource (DR).

ComEd's basic philosophies on islanding protection are:

- The protection system shall ensure that safety is not compromised.
- The protection system shall ensure that in the event of an electrical island customers do not suffer degraded voltage or frequency. The non-generating customers served from the same line should not experience any degraded service after the DR is added to the line.
- The protection system shall ensure that damage to ComEd equipment will not occur due to the addition of the DR.
- The protection system should be planned to detect only the abnormalities that mandate a separation between the DR and the supply line. Normal plant operation and normal supply line operation should not cause any form of unwanted tripping. For example, switching of capacitor banks, faults on other lines, sudden losses of customer load, and automatic load tap changing should not cause interface protective devices to operate.
- The connection and protection applied should not lessen or complicate the ability of the operating dispatcher or line crews to quickly respond to system events or in general to run the system.
- The interface protection should be appropriately balanced between risk minimization and installation cost. For example, a requirement that the interface transformer be changed to a wye connected high-side for every distributed resource project would be too costly yet it would eliminate overvoltage issues on 12kV distribution circuits.

ComEd has approximately 4700 12kV or 4kV distribution circuits with the vast majority being 12kV. Of these 4700, 124 (2.6%) are dedicated grid feeders, and an estimated 200 (4.3%) feed spot networks. Spot and grid networks may feed multiple customers. New spot or grid network services are costly to install compared to other options and it is difficult to plan efficient use of substation and circuit capacity for network circuits versus other service options. ComEd only adds new network circuits if specifically called for and paid for by the customer.

IEEE 1547 does not give any guidance for interconnection of DR to grid networks. At this time, the topic is "under consideration for the future". In addition, the proposed ICC rule that essentially follows the Federal NOPR does not specifically address connection of DR to grid networks either. Thus, this paper will address spot networks only.

The basic design of a ComEd spot network vault includes the network transformer (delta high side, wye low side) with the network protector mounted directly to the transformer. The 12kV connection to the transformer allows for disconnection of the transformer by

manual means only. Multiple network transformers and protectors are generally located in a single vault room.

Protection in the network vault consists of a number of items:

- Because there is generally no space for a 12kV interrupting device, no local interruption of 12kV faults is possible. 12kV faults are cleared via remote relaying at the source substation. Instantaneous relaying is applied at the remote substation to clear these faults as quickly as possible.
- Since the high side of the network transformer is a delta winding, the network transformer will not supply fault current to a 12kV ground fault once the source substation circuit breaker opens. A reverse power relay is applied on the 480 volt side of the protector with a sensitive pick up setting (less than the magnetizing power of the network transformer, ~ 0.1% of transformer nameplate) and a time delay ranging from instantaneous to ~ 2 seconds to detect this condition. The reverse power relay will also automatically open the protector if the source station circuit breaker is opened for reasons other than faults on the 12kV line (i.e. a source station bus fault).
- Fuses protect for 480 bus faults. These fuses must allow full load to flow on the network transformer. Since the full load capacity of a 2500 KVA transformer is approximately 3000 amps at 480 volts, a 2500 KVA network transformer fuse must be larger than 3000 amps. The fault current due to an arcing 480 volt fault can easily be less than the fuse rating. These faults must continue to arc until they extinguish or until the damage caused by the fault becomes severe enough to cause the interrupting device (the fuse) to operate.
- The great majority of ComEd's network protector devices have been installed for at least 20 years. IEEE Standard 1547 "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems" states the following in the first paragraph of section 4.1.4.2 on Distribution secondary spot networks:

Network protectors shall not be used to separate, switch, serve as breaker failure backup or in any manner isolate a network or network primary feeder to which DR is connected from the remainder of the area EPS, unless the protectors are rated and tested per applicable standards for such an application." This quote states and recognizes that a control system is not a substitute for a properly rated interrupting device. In IEEE 1547, the quote provides a footnote referring to IEEE 37.108 "IEEE Guide for Protection of Network Transformers" for guidance on the capabilities of network systems to accept distributed resources. IEEE 37.108 section 9 discusses this in greater detail as well as pointing out additional issues with DR on network circuits.

Protection Issues with DR in ComEd vaults:

The main protection issue in these vaults is the possible inability of the protectors to interrupt fault or load current between two points that are not locked together in synchronism. Faults have occurred in network protectors on ComEd's system. As described above, the area between the network protector and the network transformer is unprotected and a fault must become more severe (possibly including failure of the network transformer) to be detected. ComEd personnel working in these types of vaults have been seriously injured during faults. Faults in ComEd's network vaults have resulted in fires and extensive damage. In 1991, a DR installation in New Mexico caused reverse power to flow through all 8 of the spot network protectors while

synchronizing with the utility grid. The network protectors tripped and one protector faulted due to its' inability to separate out of phase sources. The protector suffered extensive damage. Extensive, expensive modification of an existing ComEd vault would be required to eliminate these potential hazards. Control systems cannot take the place of a properly rated interrupting device.

It has been ComEd's experience that a DR installation's circuit breaker could fail, the DR protective relay or relays could fail, the DR's power source to trip the circuit breaker could fail, and etc. A DR installation on a ComEd radial feeder recently experienced a failure that caused its inter-tie circuit breaker to close and open hundreds of times until it failed. There were no abnormalities on ComEd's system at the time of the event to cause the failure. ComEd equipment or other ComEd customers experienced no negative effects during this event.

A serious concern is the arcing 480 volt fault. As stated above, 480 volt arcing faults can limit the fault current to a level undetectable by protective fuses. These faults when undetectable must become more severe or burn clear. 480 volt faults can not be counted on to burn clear. The spacing allotted in many vaults is not adequate to assure that this will occur. Faults that must become more severe will certainly cause more damage up to and including damage to the network protector and network transformer. Introduction of DR with interrupting devices not rated to separate out of phase systems would add to the likelihood of these types of faults.

Introduction of DR to spot networks could also lead to more frequent operation of network protectors as on-site generation responds to varying loads. Network protectors could stand open due to a DR source for long periods of time. Should a DR fail during this time period, the customers fed from the network would experience an outage until the network protectors close back in. The continual cycling of a network protector can cause the close motor of a network protector to fail. This would not be known until the generator is tripped off, resulting in an outage to the customer and an extended loss of the utility service. As an example, the utility sources for network at O'Hare airport used to come from separate substations that had a slight phase angle difference. At light loads the protectors would cycle frequently and many protector motors were damaged.

DR on the line side of a spot network feeder:

Installation of DR on the line (source) side of a spot network feeder can cause issues similar to those encountered when DR is connected on the load side of the feeder. For example, a DR installed on the line side of a spot network feeder can cause reverse power flow through a two transformer spot network vault. This can occur if a ComEd source circuit breaker to the DR installation is opened due to a bus fault, due to a ground fault on the feeder with the DR, inadvertently, or for other reasons. Thus, ComEd treats these installations similar to load side connections.

The future of DRs supplied from the low voltage network at ComEd:

ComEd's DG (Distributed Generation) book currently states, "Parallel generator operation will not be allowed if the ComEd supply is from a low voltage network center or from a line that supplies network centers." The current network system components at ComEd were clearly not designed to accommodate DR. Events caused by DR connected to spot networks at other utilities with similar systems have resulted in

extensive damage. Faults in ComEd's vaults have also resulted in significant damage. Injuries have occurred when personnel were present at the time of the fault. Safety of ComEd personnel working in vaults is a paramount concern. ComEd has made comments to the Federal NOPR and the ICC draft rule on screens regarding DR on spot networks. ComEd has accepted the primary and secondary screens regarding small inverter based generation on spot networks. These levels of inverter based DR will not negatively affect reliability or safety. Some utilities do allow slightly larger DR including synchronous and induction machines to connect to their spot networks if certain screens and equipment requirements are met. It is not clear, however, whether the facilities at these other utilities (protector ratings, vault design, bus spacing, etc.) impose the same constraints on connected DR as ComEd's existing infrastructure. To the best of our knowledge, there is also no consensus on allowed size criteria, etc. Network vault design and installed network equipment capabilities may vary widely between utilities.

IEEE 1547 lists a number of general criteria to meet prior to allowing DR on secondary spot networks but does not specify how to meet them. ComEd was represented on the committee that drafted both IEEE 1547 and IEEE C37.108. ComEd continues to be represented on the committee that is continuing the application work related to IEEE 1547. It is ComEd's intention to incorporate the requirements of both of these standards in the next revision of its DG blue book. Along with this revision, ComEd will continue to develop general guidance, equipment requirements, and screens and will continue to evaluate any proposed projects.

Prepared by ComEd Protection Services
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